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ACTIVATED STEMMING DEVICE

BACKGROUND OF THE INVENTION

This invention is concerned generally with the breaking of rock and more particularly is concerned with the provision of stemming in order to confine high pressure forces, in a drill hole, which are generated during a rock breaking process, such as a tailored low energy method of breaking rock.

As used herein the word "rock" includes rock, ore, coal, concrete and any similar hard mass, whether above or underground, which is difficult to break or fracture. It is to be understood that "rock" is to be interpreted broadly.

A number of techniques have been developed for the breaking of rock using non-explosive means. These include a carbon dioxide gas pressurisation method (referred to as the Cardox method), the use of gas injectors (the Sunburst technique), hydrofracturing and various methods by which cartridges containing energetic substances pressurise the walls or base of a sealed drill hole to produce a penetrating cone fracture (known as PCF).

These techniques can be an order of magnitude more efficient than conventional blasting in that they require approximately 1/10 of the energy to break a given amount of rock compared to conventional blasting using high explosives. The lower energy reduces the resulting quantity of fly rock and air blast and to an extent allows the rockbreaking operation to proceed on a continuous basis as opposed to the batch-type situation which prevails with conventional blasting.

Most non-explosive rockbreaking techniques rely on the generation of high gas pressures to initiate a tensile fracture at the bottom of a relatively short drill hole. If the force which is generated by the high gas pressure can be optimally used then the efficiency with which rock is broken is increased.

It is customary to confine the pressure generated by the combusting propellant by making use of stemming which is placed in a blast hole and which is consolidated by tamping. Nonetheless the stemming is capable of moving to some extent under the action of the forces which are generated when the propellant ignites. The degree to which the stemming confines the forces can have a considerable influence on the effectiveness of the propellant in breaking rock.

SUMMARY OF INVENTION

The invention provides stemming apparatus which includes a member, a propellant charge and an initiator for igniting the propellant charge which then acts on the member in a predetermined direction.

In one form of the invention the member is driven by the ignited propellant charge in the predetermined direction.

The member may be shaped and include a tapered leading end or formation on a side which faces in the predetermined direction.

Preferably the member is conically shaped on the tapered leading end.

An opposing side of the member, ie. on a side which is remote from the tapered leading end, may be planar or recessed or shaped in any appropriate way.

The member may be constructed so that it is capable of flaring outwardly when moved in a direction which is opposite to the predetermined direction.

In a different form of the invention the member is shaped so that a gas generated force is produced by the ignited propellant in a direction which is opposite to the predetermined direction.

With this form of the invention the member may include a recessed formation which contains the propellant charge. The recessed formation may be substantially conical.

The member may be made from any appropriate material and, for example, may be made from a high density plastics material, a metallic material or the like.

Control means may be provided for controlling the firing of the said initiator. The control means may include an energy source and a timer for applying energy from the energy source to the initiator at a predetermined time.

The invention also provides a method of stemming which includes the steps of placing stemming material in a hole over a cartridge which includes a first propellant charge, positioning at least one member on the stemming material, locating a second propellant charge on or in the member, and igniting the second propellant charge at a predetermined time relatively to the time at which the first propellant charge is initiated.

Depending on requirements a short time interval eg. less than 5 milliseconds may exist between the time at which the second propellant charge is ignited and the time at which the first propellant charge is initiated. It is also possible for the first

propellant charge to be initiated substantially at the same time as the second propellant charge is ignited.

The member may be of any appropriate type and for example may be of a kind which has been described in connection with the aforementioned stemming apparatus.

In one form of the invention the member is between the stemming material and the second propellant charge. In another form of the invention the second propellant charge is between the stemming material and the member.

The second propellant charge may be used to drive the member in a direction towards the cartridge.

Alternatively the second propellant charge is used to produce a gas generated force which is directed towards the cartridge.

The second propellant charge may be ignited at a predetermined time relatively to the time at which the first propellant charge is initiated. The second propellant charge and the first propellant change may be initiated substantially simultaneously or within a predetermined period of the initiation of the first propellant charge. The method may include the step of precisely controlling this predetermined period.

The method may include the step of placing stemming material over the propellant charges in the hole prior to ignition of the propellant charges.

A confinement member may be placed over the propellant charges and the additional stemming may be placed over the confinement member.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is further described by way of examples with reference to the accompanying drawings in which;

Figure 1 is side view in cross section of stemming apparatus according to one form of the invention being used in a rock breaking process;

Figure 2 is a view similar to Figure 1 but illustrating a different form of the stemming apparatus according to the invention;

Figure 3 illustrates a control mechanism for use with the stemming apparatus of Figure 1 or Figure 2;

Figure 4 is a side view in cross-section illustrating the use of stemming apparatus according to the invention during a rock breaking process; and

Figure 5 is a schematic illustration of a control mechanism used for controlling, on a time basis, a rock breaking process.

DESCRIPTION OF PREFERRED EMBODIMENTS

Figure 1 of the accompanying drawings illustrates the use of stemming apparatus according to one form of the invention during a rock breaking process.

In order to implement the rock breaking process a hole 10 is drilled into a rock mass 12 from a face 14 using conventional drilling equipment, not shown. The hole is drilled to a predetermined length which is at least four times the nominal diameter of the hole.

A cartridge 16 is loaded into the hole. The cartridge has a base 18 which opposes a bottom 20 of the hole and a generally cylindrical wall 22 which extends upwards from

the base and which, at an end which is remote from the base, has a rounded shape 24.

The cartridge is made from a malleable material which in this specification means a material which is capable of plastically deforming, without rupturing, at least to a predetermined extent eg. by at least 10%. By way of example the cartridge may be made from a high density plastics material such as high density polypropylene.

The cartridge 16 forms an enclosure for a propellant material 26 which is of known composition and which is loaded into the cartridge under factory conditions using techniques which are known in the art. An initiator 28 is loaded into the cartridge.

Control wires 30 lead from the initiator to a control unit, not shown, which is used in a known manner for initiating the blasting process.

Stemming 32 is placed into the hole 10 from the rock face 14 covering the cartridge to a desired extent. The stemming is consolidated by being tamped in position. The nature of the stemming and the way in which it is tamped are known in the art and for this reason are not further described herein.

A member 34, which is made from a plastics material such as polypropylene, is then placed over the stemming 32. The member has a conical leading end 36 which faces downwardly into the stemming and, in this example, has a substantially planar trailing end 38 which faces upwardly. The maximum diameter of the member 34 is slightly less than the nominal diameter of the hole 10.

A propellant charge 40 is placed on the member or, preferably, is incorporated in the member under factory conditions. An initiator or igniter 42 is engaged with the

propellant charge. Control leads 44 lead from the initiator to the control unit which is used for firing the initiator 28.

When the initiator 28 is energised the propellant 26 in the cartridge combusts and causes the release of high pressure jet material which is substantially in gaseous form. The cartridge 16 expands outwardly and deforms, initially without rupturing, to confine the high pressure gas up to a stage at which the cartridge fractures at which point the high pressure jet material is released to cause fracture of the rock at one or more points at which high pressure stress regions are created. At this stage substantial force is exerted on the stemming 32 and as the stemming is radially confined there is a tendency for the stemming to move upwardly and out of the hole.

This embodiment of the invention provides a technique for counteracting the force which tends to drive the stemming out of the hole and which originates from the propellant 26. This is achieved by firing the initiator 42 to initiate the propellant charge 40. When this occurs a force is applied to the trailing side 38 of the member and it is driven downwardly into the stemming 32 thereby producing a force which counteracts the upwardly directed force which is produced by the propellant 26. If the propellant charge 40 is ignited at a precisely determined time relatively to the instant at which the propellant 26 is ignited then the pressure waves which are transmitted through the stemming 32 from the propellant material 40 and from the propellant 26 on the other hand can, at least to a substantial extent, be cancelled out. This means that the tendency of the stemming 32 to move out of the hole is restricted and the high pressure jet material which is released by the propellant 26 is confined to a substantial extent. Significantly higher pressures are therefore generated inside the confined volume occupied by the expanding cartridge and, as a

consequence, higher forces are generated to fracture the rock in the region of the cartridge.

When the propellant 40 is ignited the member 34 is driven downwardly. In order to enhance the force which is exerted on the member additional stemming 50 may be placed over the member and the propellant material before deflagration takes place. Although there is a tendency for the material 50 to be expelled from the hole 10 the stemming nonetheless provides a restraining force which helps to increase the net force acting on the member 34.

The arrangement shown in Figure 2 is similar in many respects to what is shown in Figure 1 and where applicable like reference numerals are used to designate like components.

In the Figure 2 arrangement the member 34 has a conical leading end 36 but, on a trailing side, has a recessed formation 52. The propellant charge 40 and the initiator 42 are located in the recessed formation. As has been described in connection with Figure 1 stemming 50 is preferably placed over the member 34 and the propellant charge before ignition of the propellant charge takes place.

When the charge is ignited the member 34 is driven downwardly thereby assisting in confining the underlying stemming 32. The member 34 is however shaped so that there is a tendency for the member to expand radially outwardly when the member is driven towards the mouth of the hole. This may occur for example if the force which is released by the propellant 26 in the cartridge is significantly greater than the force which is produced by the propellant charge 40. A similar situation may also arise if the times at which the propellant 26 and the propellant charge 40 are initiated are

such that there is no significant cancellation of the oppositely directed forces produced by these materials.

It is apparent from the aforegoing that it is highly desirable to be able to control precisely the time at which the propellant charge is ignited with respect to the time at which the propellant 26 is initiated. This can be achieved in a variety of ways and Figure 3 illustrates, somewhat schematically, a suitable control technique.

Figure 3 shows a control unit 60 which is connected to the control wires 30 and which is used to generate an electrical signal which is applied to the initiator 28 associated with the cartridge 16. The control wires 44 shown in Figure 1 lead to a component 62 which is associated with the propellant charge 40. The component 62 contains a capacitor 64 which is charged, preferably beforehand, by energy supplied by the control unit 60.

When a suitable further control signal is generated by the control unit 60 a timer 66 in the component 62 is started and after a predetermined time interval, which is programmed beforehand, the capacitor 64 is caused to discharge by closure of a switch 68, included in the timer, which then applies the energy stored in the capacitor to the initiator 42 which causes the propellant charge 40 to be fired.

The initiator 28 may have a similar timing mechanism associated with it. Alternatively the initiator 28 may be directly fired by means of a control signal from the control unit and this control signal may be used to start the timer 66 to ensure that the initiator 42 is fired a short interval after the initiator 28 is fired. Clearly this technique can be reversed in that the initiator can be fired directly by means of a control signal from the control unit and the initiator 28 can then be fired a short

interval after the propellant charge is ignited. The important aspect here is that it is possible, through the use of suitable control techniques, to fire the propellant charge 40 and the propellant 26 within predetermined time intervals of each other in order to ensure that the pressure wave which is transferred to the stemming 32, by the propellant 26 is effectively counter-balanced by the member 34 which is driven into the stemming by the propellant charge 40.

Figure 4 illustrates another variation of the invention. A hole 110 is drilled into a rock mass 112 from a face 114 using conventional drilling equipment, not shown. The hole is drilled to a length which is at least four times the nominal diameter of the hole.

A cartridge 116 is placed into the hole. The cartridge has a base 118 and a generally cylindrical wall 120 which extends upwards from the base and which, at an end which is remote from the base has a rounded shape 122.

The cartridge forms an enclosure for a propellant material 124 which is of known composition and which is loaded into the cartridge under factory conditions using techniques which are known in the art. An initiator 126 is loaded into the cartridge, preferably on site. Control wires 128 lead from the initiator to a control unit 130 which is located at a remote and safe position.

Stemming 132 is placed into the hole from the rock face 114 and covers the cartridge to a desired extent. The stemming is consolidated by being tamped in position.

In this example of the invention the base 118 of the cartridge is in close contact with a bottom 134 of the hole. The intention in this regard is that the stemming should confine the cartridge on one side while the surrounding surface of the rock 112 should confine the cartridge on its remaining sides.

A shaped member 140 is placed in the hole over the stemming 132. The member is made from a plastics material and includes a downwardly facing recessed formation 142 which, in this example, is substantially conical. A propellant charge 144 is loaded into the formation 142, preferably under factory conditions. An initiator or igniter 146 is engaged with the member 140 and control wires 148 lead from the initiator to the control unit 130. Preferably additional stemming 150 is placed into the hole over the member 140 and is consolidated by being tamped downwardly.

Ignition of the propellant 124 by the initiator 126 causes the release of high pressure jet material which is substantially in gaseous form. The cartridge 116 is designed to contain the expanding high pressure material and for this reason is allowed to deform outwardly, without initially rupturing, so that the wall 120 of the cartridge is forced into close contact with an opposing surface of the wall of the hole. The cartridge does not fracture during this process for it is fabricated from a plastically deformable material.

The function of the cartridge, in this respect, is to confine the high pressure gas for a limited period. The function of the stemming on the other hand is to contain, to the maximum extent possible, the high pressure jet material which is released when the cartridge fractures. The force which is generated by the high pressure jet material and which is applied to the stemming 132 is substantial and can cause the stemming 132 to be displaced to a significant extent in the hole 110. If movement of the stemming can be restricted then the pressure which is generated in the cartridge 124 can be contained so that the resulting force exerted by the high pressure jet material is increased.

In order to counteract the pressure wave which is exerted on the stemming 132 by the combusting propellant 124 the propellant 144 is ignited at a precisely determined

time relatively to the time at which the propellant 124 is ignited. This is done by applying a suitable control signal, generated by the control unit 130, through the control wires 148 to the initiator 146.

The deflagrating propellant 144 directs a pressure wave into the stemming 132 which is timed and which is of a magnitude such that this pressure wave substantially counter-balances the pressure wave which is exerted on the stemming by the propellant 124. The result is that the stemming 132 is effectively held stationary and maximum energy is extracted from the propellant 124 and applied to the surrounding rock 112 in order to crack the rock in an effective manner.

The member 140 helps to direct the pressure wave generated by the propellant 144 into the stemming 132 and the stemming 150, in turn, helps to confine the member in the hole.

If the pressure waves produced by the propellant 124 on the one hand and by the propellant charge 144 on the other hand, are to be balanced, then it is important for the pressure waves to be essentially of the same magnitude, taking into account the resistive forces which are exerted by the stemming, and for the pressure waves to be generated at precisely controlled intervals. The control mechanism shown in Figure 5 is intended to provide the timing function to achieve this balancing effect.

The control mechanism, designated 160, is connected to the control unit 130 shown in Figure 4 by means of the control leads 128 and 148. The control mechanism includes a capacitor 162 which is charged, beforehand, by means of a suitable charging voltage which is applied via the leads 148 to the capacitor. The mechanism further includes a timer 164 which is turned on, to start a timing interval of a predetermined duration, by means of a control signal applied via the wires 148 from

the control unit. At the end of the timing interval a switch 166 in the timer is closed and the capacitor is caused to discharge through the closed switch and direct the discharged energy into the initiator 146 which is associated with the propellant 142. The control signal which is used to start the timer can also be used to fire the initiator 126. In this arrangement it is apparent that the igniter 146 will be fired a short interval after the initiator 126 is fired. It is possible however to reverse the sequence of operations in that the igniter can be ignited before the initiator 126. The sequence of operations in this regard is determined by the aforementioned requirement in that, as noted, the two pressure waves must be generated in such a way that they effectively meet and counteract each other within the mass of the stemming 132.